

METHODOLOGIES



Sealing ability of mineral trioxide aggregate and Biodentine as the root end filling material, using two different retro preparation techniques - An *in vitro* study

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Abstract

Aim: The purpose of this study is compare sealing ability of mineral trioxide aggregate (MTA) and Biodentine as root end filling material, and also to compare the effect of different retro preparation techniques i.e. conventional burv/s ultrasonic tips on sealing ability of both the root end filling materials. **Materials and Methods:** Totally, 40 extracted human single rooted teeth were decoronated, and root canal treatment was performed. Teeth were stored in saline for 1 week. Following which, root ends were apically resected at 90° angle to a long axis of the root and prepared. The samples were randomly divided into two groups of 20 specimens each. Group I: MTA, Group II: Biodentine as the root end filling. Each group was subdivided as A - round bur preparation and B - ultrasonic tip root end preparation. Samples were stored in saline for 48 h and then immersed in 0.5% rhodamine B dye for 24 h, sectioned and evaluated for leakage under confocal laser scanning microscope. **Results:** Statistical analysis of readings was done using factorial ANOVA. Biodentine and ultrasonic preparations showed significantly less microleakage than MTA and bur preparations. **Conclusion:** Biodentine can be used as a replacement for MTA, as a root end filling material.

Keywords: Biodentine, confocal laser scanning microscope, microleakage, mineral trioxide aggregate

Introduction

Success of endodontic treatment mainly relies on complete three dimensional sealing of the root canal system in order to achieve fluid tight seal.^[1] However, in certain clinical situations, resolution of periapical pathology through non-surgical approach is unsuccessful. In those situations, surgical intervention is the treatment modality of choice.

Surgical approach is commonly indicated in situations such as persistence of periapical pathology, overfilled canals, ledges, canal obstructions, separated instruments, apical transportations and perforations. Treatment involves root end resection, retro cavity preparation followed by insertion of a root end filling material.^[2]

One of the pre-requisites for the success of surgical endodontics relies on selection of root end filling material having beneficial properties such as biocompatibility, good strength, optimum sealing ability, promote healing, radiopacity, easy manipulation and should not get affected by the presence of moisture.^[3]

Endodontic literature describes various materials used as root end filling such as amalgam, glass ionomers, composite resins, zinc oxide eugenol cement, cavit, intermediate restorative material (IRM), super ethoxy-benzoic acid (EBA), and mineral trioxide aggregate (MTA). However, till date no single material has been able to fulfill all the requirements of an ideal root end filling material.^[4]

Of all these root end filling materials used, MTA is the material of choice because it satisfies almost all the criteria's including excellent sealing ability, biocompatibility, ability to set in the presence of moisture, radiopacity. But it also possess certain drawbacks such as long setting time (2 h 45 min), difficulty in its manipulation and it is quite expensive, which has led to the quest of searching an alternative material as a root end filling.^[5]

Researchers have developed a new active calcium silicate-based material named Biodentine (Septodont), which claims to have beneficial properties such as excellent sealing ability, biocompatibility, good dimensional stability with the added

advantage of short setting time, improved mechanical strength easy manipulation and quite economical thereby fulfilling the drawbacks of MTA and therefore can be thought to be used as root end filling material. Till date, literature review has not reported any studies with regards to Biodentine as the root end filling material.

Apart from the root end filling material, the other important aspect important for clinical success of surgical endodontics relies on the type of retro preparation technique used. Conventionally root end preparation using micrburs showed high microleakage that has led to the introduction of ultrasonic retrotip root end preparation. It has the advantage of creating a better-shaped conservative, smooth, deep and more centrally placed cavity, and it decreases the number of exposed dentinal tubules at the resected root surface thereby reducing apical leakage.^[6]

Aims and objectives

The aims of this study were:

1. To evaluate the microleakage and compare the sealing ability of MTA and Biodentine as the root end filling material
2. To compare the effect of different retro preparation techniques, i.e. conventional bur and ultrasonic tips on sealing ability of MTA and Biodentine.

Materials and Methods

Forty intact extracted human single rooted teeth with completely formed apices were collected, cleaned and decoronated at cemento-enamel junction using a diamond disk. Preoperative radiographs were taken to check for the root canal anatomy. Access cavities were prepared using small round bur. No. 10 K-File was inserted into root canals 1 mm beyond the apical foramen to confirm canal patency. Then working length established 1 mm short of the apex followed by coronal enlargement using GG drills. Canals were prepared using Crown down technique using 3% sodium hypochlorite irrigating solution. Canals were enlarged up to No.40 K file using RC Prep. Canals were dried using absorbent paper points, and master cone selection was confirmed with radiographs. Canals were obturated with 2% gutta percha using a zinc oxide eugenol sealer by lateral compaction technique. Radiographs were taken to confirm the quality of obturation and the access cavities were sealed with Cavit.

Teeth were then stored in saline for 1 week and then resected apically at 90° to the long axis of the root using straight fissure bur removing 3 mm of the apex.

Then all teeth were divided into two groups of 20 specimens each.

In 20 specimens, 3 mm retro cavity was prepared using No. 2 carbide bur and in remaining 20 specimens, 3 mm retro cavity was prepared using ultrasonic tips.

Groups

Group I: MTA used as root end filling material in which root end was prepared by:

- IA: Round bur used

- IB: Ultrasonic retrotip used.

Group II: Biodentine used as root end filling material in which root end was prepared by:

- IIA: Round bur used
- IIB: Ultrasonic retrotip used.

Both the materials were mixed according to manufacturer's instructions and cavities were filled using MTA carrier. Specimens were stored at 37°C with 100% humidity for 48 h and then were coated with two coats of nail varnish except at the root end and were allowed to dry.

Dye preparation

About 2% solution of rhodamine B dye was prepared by dissolving 2 g of dye to 100 ml of distilled water.

The specimens were immersed in prepared 0.5% aqueous solution of rhodamine B dye for 24 h, dye was then rinsed with water for 15 min to remove excess dye. Specimens were sectioned longitudinally through center of tooth with diamond disc. Buccal half of the teeth sections were retained, discarding the lingual half of the teeth.

Tooth-root end filling material interface was observed for the extent of dye penetration under confocal laser scanning microscopy and microleakage associated with all groups was evaluated in millimeters. Statistical analysis of the data was done using factorial ANOVA.

Confocal images

1. Group I(A): MTA + Bur preparation [Figure 1]
2. Group I(B): MTA + Ultrasonic preparation [Figure 2]
3. Group II(A): Biodentine + Bur preparation [Figure 3]
4. Group II(B): Biodentine + Ultrasonic preparation [Figure 4].

Results

Higher mean microleakage (mm) was recorded in MTA compared to Biodentine and the difference between them was statistically significant ($P < 0.01$) as shown in Table 1.

It can be observed in Graph 1 that:

1. Between materials - Mean microleakage is higher in MTA filling material compared to Biodentine material
2. Between preparation techniques - Round bur showed a higher mean microleakage compared to ultrasonic when used with either Biodentine or MTA filling material

Table 1: Statistical analysis of mean microleakage (mm) recorded in all the groups

Filling material	Root end preparation	Mean	Standard deviation	SE of mean	Median	Min	Max
MTA	Round bur	0.77	0.15	0.05	0.75	0.50	0.98
	Ultrasonic	0.72	0.13	0.04	0.73	0.50	0.95
Biodentine	Round bur	0.56	0.15	0.05	0.59	0.30	0.79
	Ultrasonic	0.53	0.23	0.07	0.53	0.00	0.79

MTA: Mineral trioxide aggregate, SE: Standard error

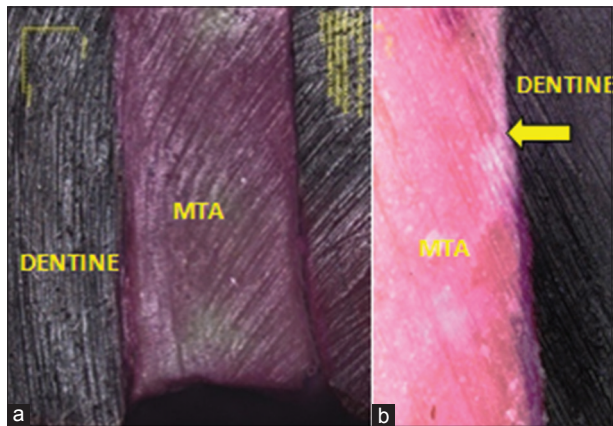


Figure 1: Confocal image of Group I (A) sample showing dye penetration, (a) $\times 10$ image, (b) $\times 20$ image. Arrow indicating depth of dye penetration

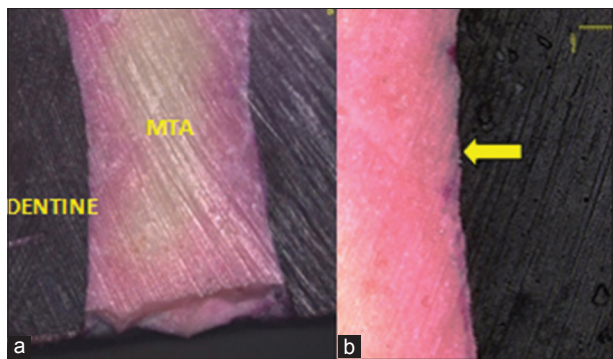
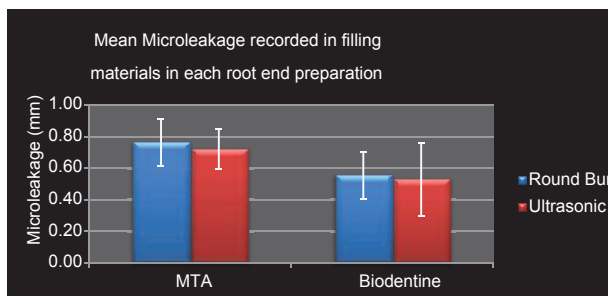


Figure 2: Confocal image of Group I (B) sample showing dye penetration, (a) $\times 10$ image, (b) $\times 20$ image. Arrow indicating depth of dye penetration



Graph 1: Microleakage recorded in all experimental groups

- Between filling materials along with preparation techniques – Mean microleakage is minimum with Biodentine with ultrasonic preparation, followed by Biodentine with bur preparation, then followed by MTA with ultrasonic preparation and maximum leakage with MTA with bur preparation
- The lowest mean microleakage is observed when Biodentine with ultrasonic root end preparation and the highest mean

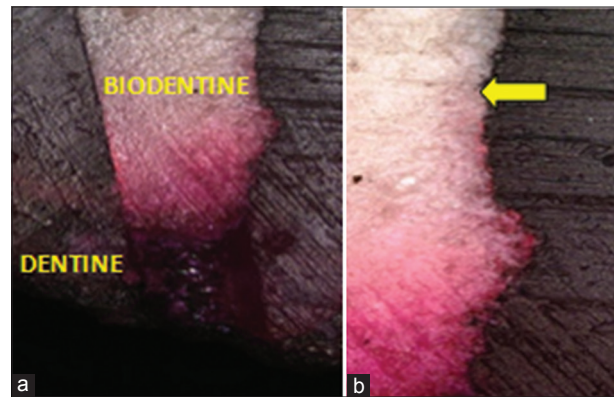


Figure 3: Confocal image of Group II (A) sample showing dye penetration, (a) $\times 10$ image, (b) $\times 20$ image. Arrow indicating depth of dye penetration

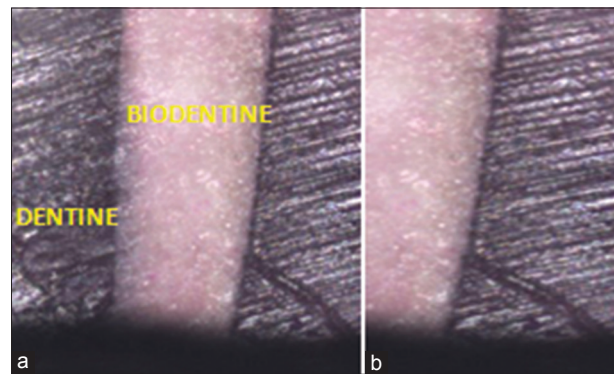


Figure 4: Confocal image of Group II (B) one of the samples showing no dye penetration, (a) $\times 10$ image, (b) $\times 20$ image

microleakage is observed when MTA is used with round bur root end preparation.

Discussion

Success of root canal treatment depends upon removal of infected canal contents by thorough cleaning and shaping followed by the obturation in order to achieve a fluid tight seal between the pulp space and the periradicular area.^[7] When this fluid tight seal cannot be obtained by an orthograde filling, surgical endodontic therapy is needed to save the tooth.^[8]

Surgical endodontic therapy comprises of thorough debridement of pathological periradicular tissue, resection of the apical end of the root followed by preparation of a Class I cavity in the resected root end and insertion of a root end filling material into the prepared cavity in order to completely seal the root end against microleakage.^[9,10]

Root end resection is an important component of endodontic surgery as it will aid in eliminating anatomical variations, resorptive defects, ledges, perforation defects, canal obstructions, and separated instruments that may be present in this area of the

root. It has been reported that resection of the apical 3 mm of the root apex will eliminate 98% of the apical ramifications and 93% of the lateral canals which could contain material that would contribute to the periradicular disease. Therefore, in this study, resection of the root was performed at the level of 3 mm from apex to eliminate any lateral canals or apical ramifications that are similar to that done in previous studies.^[11,12]

The plane of root resection is equally important consideration. Inclined plane sectioning results in open dentinal tubules that may compromise healing of the lesion. 90° angulation has therefore proved to be acceptable in earlier studies.^[13,14]

The depth of root end filing material should be 3 mm as more than that does not bestow any greater benefits whereas lesser depth may jeopardize the long-term success of apical seal. Hence, the depth of cavities in this study was depth to an optimum of 3 mm.^[15]

Root end preparation technique is also one of the important factors that greatly affect the sealing ability of the root end filling material. Cavity preparation with small burs has some drawbacks like root beveling at an angle of 45° is done leading to increased number of dentine tubules exposed favoring apex re-infection. Use of ultrasonic instruments for root end cavity preparation have solved many of these problems, improving access to the surgical field, avoiding beveling and producing a cleaner, conservative, smooth, deep and more centrally placed cavity in the root canal which decreases the number of exposed dentinal tubules at the resected root surface thereby minimizing apical leakage.^[5,16]

Apical microleakage is the most common cause responsible for failure of endodontic therapy. Therefore, it is important to prevent this by sealing the root ends with suitable root end filling material. Hence, selection of ideal root end filling material plays an important role in the success of surgical endodontics.^[17]

A wide variety of materials have been advocated for use as root end filling materials till now such as silver amalgam, zinc oxide eugenol cements (IRM and super EBA), glass ionomer cement (GIC), composite resins, and resin - glass ionomer hybrids and MTA. However, to date, no material has been found to satisfy all the requirements of an ideal root-end filling material.^[18]

MTA was developed by Torabinejad at Loma Linda University in 1993. Its major constituents are tricalcium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide, bismuth oxide, calcium carbonate. It has favorable properties suitable for an root end filling material such as excellent sealing ability, biocompatibility,^[19] good compressive strength (67 Mpa), insoluble in fluids once set, radiopacity and antibacterial effect.^[20] It has also been shown to induce hard tissue formation, including deposition of cementum.^[21] But it also has certain drawbacks like prolonged setting time (2 h 45 min), difficulty in manipulation, technique sensitivity, and it is quite expensive as well.^[22,23]

New experimental active Ca_3SiO_5 -based restorative cement is introduced by name of Biodentine™ (Septodont, Saint- Maurdes-Fosses, France). It is available in the form of powder and liquid. Powder is composed of tricalcium, dicalcium silicate,

calcium carbonate, zirconium dioxide. In liquid, calcium chloride is added in aqueous solution to increase its setting time. Both of them are mixed in triturator for 30 s prior to insertion. It sets in about 12 min. The consistency of Biodentine is similar to that of phosphate cement. It is a calcium silicate-based material used for crown and root dentin repair treatment, repair of perforations or resorptions, apexification and root-end fillings. With the addition of setting accelerators and softeners made its manipulation easy.^[24]

It also have certain advantages over MTA i.e. short setting time (12 min), easy manipulation, better compressive strength, no effect of blood contamination on its physical properties and cost effective and hence can be propagated to be used as an alternative to MTA as a root end filling material.^[24]

Various techniques have been advocated for detection and evaluation of microleakage around the root end filling material. Use of dyes as tracers is one of the oldest and most common method of detecting microleakage *in vitro* as it is inexpensive, non-toxic and leakage can be easily detected by various concentrations.^[25,26]

Rhodamine B which is water-soluble fluorescent dye which is easily detectable, even in a low concentration, moves freely along the interface, low toxicity and are stable in an aqueous environment, stable in varying pH, non-destructive to the substrate or material in contact.^[27,28]

In the present study, specimens were immersed in a 0.5% aqueous rhodamine B dye for 24 h after hemi section of the specimens longitudinally through mid-line of the root end filling material, similar to a method used in previous studies.^[29,30]

Confocal laser scanning microscope is a non-destructive technique of visualizing the extent of dye penetration. It has certain advantages in visualizing subsurface tissue features including indicating the clear indication of leakage limits, due to a lens focus that can occur some microns beneath the observed surface.^[31] It also helps in eliminating stain spread caused by specimen sectioning and reduces polishing artifacts that can increase dye penetration depth.^[32] It also eliminates the scattered, reflected and fluorescent light from various other planes, increased clarity in the focal plane.^[33]

This present study compared the sealing ability of MTA and a new experimental filling material Biodentine.

Results of the present study revealed that samples filled with Biodentine and prepared with ultrasonics showed least leakage value (0.53 mm) when compared with other experimental groups.

The probable reasons could be:

1. When Biodentine comes in contact with dentine it leads to the formation of tag-like structures alongside an interfacial layer called the "mineral infiltration zone," where the alkaline caustic effect of calcium silicate cements hydration products degrades the collagenous component of interfacial dentine.^[34]
2. The sealing ability of Biodentine is most likely through the formation of tags. Han and Okiji showed that calcium and silicon ion uptake into dentin leading the formation of tag-like structures in Biodentine was higher than MTA.^[35]

3. Better seal with Biodentine can also be attributed to its modified powder composition i.e. the addition of setting accelerators and softeners, a new pre-dosed capsule formulation for use in a mixing device largely improve the physical properties including sealing ability of the material
4. Biodentine has an advantage of fast setting time (12 min) thereby sealing the interface earlier to avoid further leakage to take place so there is a lower risk of bacterial contamination
5. Due to its better handling properties adaptation to the cavity walls is better which can be responsible for improved sealing ability of Biodentine
6. Smaller particle size of Biodentine adapts well to cavity surface sealing interface
7. Porosity and pore volume in set Biodentine material is also less than MTA that could be a reason for better sealing ability.^[36]

In a study done to check for marginal adaptation of three root-end filling materials GIC, MTA and Biodentine concluded that lowest marginal gaps and good marginal adaptation with Biodentine followed by MTA and highest marginal gaps with GIC.^[30]

A scanning electron microscope (SEM) study conducted on sealing ability of Biodentine, MTA and GIC to dentin concluded that Biodentine exhibited better marginal adaptation to dentin in comparison to MTA and GIC cements and also highlighted the influence of time on marginal adaptation.^[37]

In the present study, the sealing ability of both the filling materials is influenced by the root end preparation technique. In all the samples that were filled with either Biodentine or MTA, ultrasonically root end prepared samples showed less leakage values when compared to those prepared with bur that is similar to results found in previous studies.^[38]

This can be attributed to the condition of cavity surface left after the preparation technique. Cavities prepared with rotary burs are left with a greater amount of debris and smear layer in comparison to those prepared with diamond coated ultrasonic tips. This will prevent complete contact between filling material and cavity walls. The greater presence of this smear layer in micro bur prepared cavities helps to explain the greater leakage observed with both materials in microbur versus ultrasonically prepared cavities.^[39]

However, one of the drawbacks of using ultrasonics is the production of microcracks on root canal walls. As a generation of cracks is related to intensity of the ultrasonic device, low intensity should be preferred. No dentine tissue damage is observed at the low intensity (4 MHz) which is used in the present study. This is confirmed by the failure to detect cracks under SEM in previous studies.^[38,39]

This study was performed *in vitro* conditions, further long-term *in-vivo* studies are required to check for sealing ability of Biodentine before routine clinical usage. Also, further studies need to be done to check for nature and longevity of the bond obtained from dentine – Biodentine interface and on the effect of blood contamination on sealing of Biodentine.

Conclusion

Within the limitations of this *in-vitro* study, it can be concluded that:

1. Biodentine group prepared using ultrasonics showed best sealing than all the other tested groups
2. Irrespective of preparation techniques used, Biodentine still showed better sealing than MTA
3. Preparation of the root end using ultrasonics showed less microleakage than bur prepared teeth for both filling materials
4. Therefore, Biodentine can be used as a replacement for MTA as a root end filling material
5. However, further *in vitro* and *in vivo* studies are recommended to confirm and correlate the findings of this study to a clinical scenario.

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